Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of		
Terrestrial Use of the 2473-2495 MHz Band for Low-Power Mobile Broadband Networks; Amendments to Rules for the Ancillary Terrestrial Component of Mobile Satellite Service Systems	)	**IB Docket No. 13-213 RM-11685**

***Ex Parte* Filing of Etymotic Research Inc.**

Etymotic Research Inc. (Etymotic) is providing these comments, additional to those we filed on July 23, 2015 in this docket. This filing is largely responsive to filings since our original comments and particularly the September 10, 2015 filing of Globalstar Inc. (Globalstar) with an additional demonstration reported in that filing. The additional demonstration was performed for Globalstar by Roberson and Associates on a university campus in the Chicago area. In these comments we present the following points:

- Globalstar's proposal for a network operating system (NOS) managed by a single company, Globalstar, is based on antiquated spectrum management techniques that have been proven to no longer be effective, if they ever were effective.
- Globalstar's proposal results in a financial windfall being provided to Globalstar alone. This is a fundamental inequity and simply wrong.
- In support of its proposal Globalstar has only provided demonstrations, not rigorous testing. Further those demonstrations do not address the adequacy of

the proposed service rules. Rather these demonstrations show how some systems, operating far from the limits allowed in the proposed rules, might perform.

- The focus of Globalstar's demonstrations have been on the impact on Wi-Fi. Bluetooth, Bluetooth Low Energy and other protocols that provide real-time voice services are the most vulnerable. However, these are only addressed in a cursory fashion.
- A fundamental principle of research is to provide enough detail that results can be independently reproduced in other laboratories. However, Globalstar does not provide enough technical specification to allow independent testing.
- The interference mitigation system Globalstar proposes is to provide a hotline with human operators to accept complaints and request remedies. The remedies themselves require service personnel to go make changes. This kind of system is completely out of date and out of touch with how modern mobile communications operates and is used.

Etymotic is a manufacturer of products for people with hearing loss and to enhance people's listening experience. Our various products operate in the 2.4 GHz ISM band, using either Bluetooth or our own proprietary RF protocol. Therefore, we have an interest and concern about any changes to this band and the electromagnetic environment in which our products operate.

If the proposals from Globalstar for a Network Operating System ("NOS") are representative of its understanding of spectrum management then that understanding is both archaic and completely disconnected from the needs of current communications.

The vision of an NOS with operators, hotlines, and human management brings to mind Lilly Tomlin's portrayal of a telephone operator. For anyone unfamiliar with Ms. Tomlin's rendition of telephone operators we recommend the following skits and particularly the depiction, in the first URL, of the frustration in a service call to resolve an interference complaint:

- https://www.youtube.com/watch?v=G0l9fE2RAj8
- https://www.youtube.com/watch?v=SvesMBkduQo
- https://www.youtube.com/watch?v=P3AujuB_3Zs

Figure 1 - Lilly Tomlin as a telephone operator[1]

Our customers are representative of many users of unlicensed products. They are mobile. They use our products when and where needed. Our Companion Mic system is an example of the kind of service that needs to be considered when designing an interference

[1] Image copied from https://afeatheradrift.wordpress.com/2009/06/03/the-funnest-game-in-town/

mitigation function. The Companion Mic system was developed to improve speech in noisy places such as restaurants, convention centers, airport terminals and family gatherings. Our quality of life depends on our ability to communicate with family. friends, colleagues and business associates. When the ability to communicate is compromised many people withdraw from conversation. With the Companion Mic system, those who have been excluded from conversation in noisy places can now enjoy social situations and fully participate again. However, it is precisely these noisy places that are the most likely to have high RF levels and be deployment targets for Globalstar, threatening the ability of our Companion Mic system and other similar products to provide their benefit.

Figure 2 - Etymotic Research Companion Mic System is designed to allow people to talk in noisy places like restaurants, convention centers, airport terminals and other gatherings.

The places people meet already tend to be acoustically noisy, making it hard for people with hearing loss to hear and communicate. Such places also tend to have a lot of wireless activity. If both the acoustic and RF environment are simultaneously congested then people with hearing loss will be excluded once again.

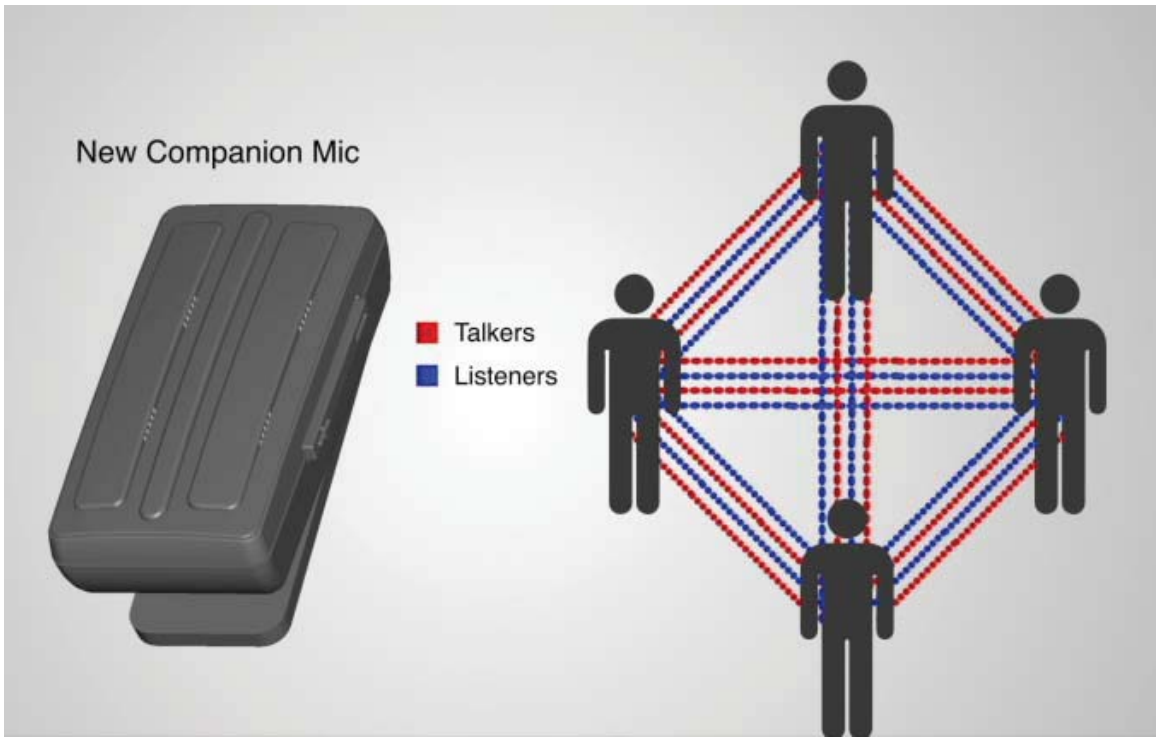

Figure 3 - Etymotic Research's Companion Mic allows people with hearing loss to participate in conversations by overcoming background noisy using wireless transmission of the desired speech.

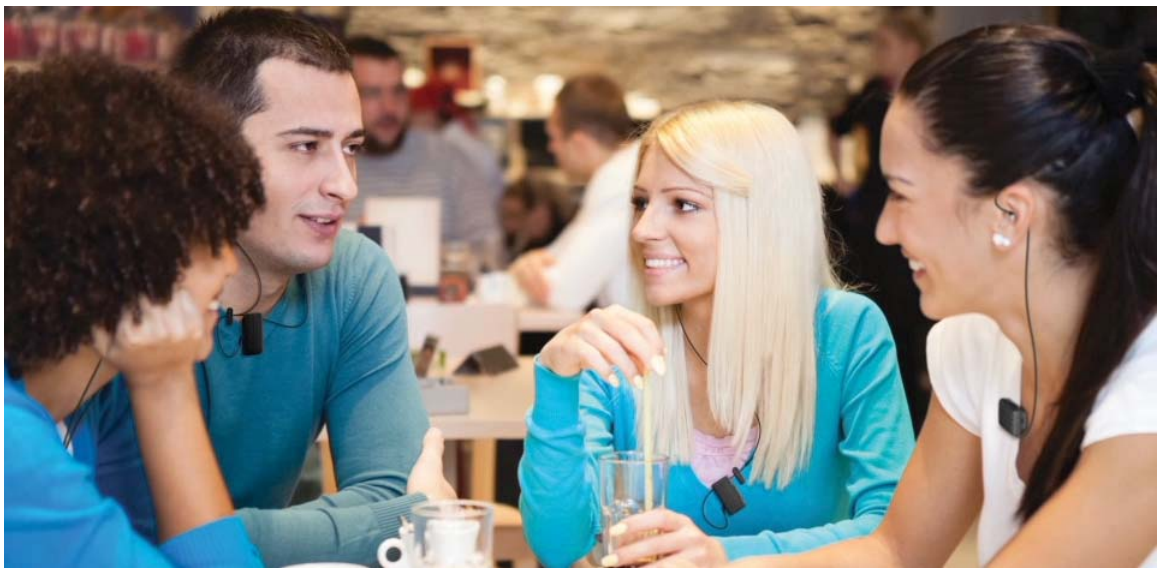

Figure 4 - Those who have been excluded from conversation in noisy places can enjoy social situations and fully participate again so long as the RF transmission is not also blocked.

To be effective, interference mitigation must be able to resolve interference in milliseconds, not hours or days. Network management methods exist that meet the needs of modern mobile communications. Existing methods do not require a single company to

be granted economic advantage so that they can serve as the network manager. We would point to the interference management built into the Wi-Fi and Bluetooth standards and the spectrum etiquette the Commission has implemented for the UPCS band. All of these have automated methods for detecting and mitigating interference built into the structure of the networks.

We have a growing concern about the financial inequity that will results should this NPRM be approved. This proposal delivers immense value to a single company with no compensation to the taxpayer or, perhaps most importantly, the users of other services in that band. In contrast, under their proposal Globalstar would be given spectrum others are required to pay very high prices for. As Globalstar makes clear in its September 10, 2015 filing, only its own subscribers will benefit from the free spectrum that will be given them:

> The NOS will authenticate users to ensure that only authorized users have access to network resources. [2]

Many sectors and industries desire spectrum to socially critical functions. Medical device manufacturers would like additional dedicated spectrum to support a variety of healthcare delivery services. The hearing instrument industry would like dedicated spectrum to serve the needs of people with hearing loss. The list of industries and companies seeking operating spectrum is long. When the Bluetooth SIG says:

> It is wrong that one company can have its own rules for operating in the ISM band when tens of thousands of other companies are obliged to follow a different set of rules. Wrong in principle and wrong for the industry to allow this.[3]

we agree. Giving control of very valuable spectrum to a single company without any price or competitive bidding is wrong. We believe it would be even more wrong to allow

[2] Globalstar filing in FCC IB Docket 13-213, dated September 10, 2015, pg. 2 of the TLPS NOS Management Annex.
[3] Comments of the Bluetooth SIG filed in FCC IB Docket 13-213, dated October 23, 2015, pg. 1.

the resulting degradation in service to those depending on their own existing use in that bandwidth for help in hearing and for medical support. The only apparent beneficiaries would be those subscribing to Globalstar services, a benefit obtained at the expense of millions of innocent persons who trust the Commission to make fair decisions.

Beside the inequity of a making a spectrum gift to a single company there is a fundamental flaw in the demonstrations being provided by Globalstar in support of the Terrestrial Low Power Service ("TLPS") system. That flaw is to the provision of only demonstrations, not rigorous testing: demonstrations showing the interference potential of specific implementations of TLPS but not even attempting to speak to the issue of whether the proposed service rules will provide adequate interference protection. The only limits on the equipment used in the TLPS system are the service rule. It is therefore the adequacy of those rules that is of paramount importance. However, Globalstar and Roberson and Associates, performing testing in support of Globalstar, fail to address this central question. It is the adequacy of the service rules that is of concern. We would further agree with the comment by the Bluetooth SIG:

> After reviewing the details of the recent Globalstar filing[4] the Bluetooth SIG makes the following observations:
>
> - The filing reports another "demonstration" by Globalstar that proves nothing and is as vague and non-transparent as the prior Globalstar demonstrations. Details of the Bluetooth testing included in their filing were almost insulting in their lack of detail and specificity. It is amazing that any conclusion could be drawn.
> - The Bluetooth SIG was also not aware of these recently conducted demonstrations, was not invited to participate (despite having made repeated offers previously) and was not consulted in the construction of a suitable and appropriate testing plan. The Bluetooth SIG can only assume that the lack of transparency and lack of industry involvement is an indication that there is real cause for concern that proper testing would expose.
> - The companies and organizations in the wireless industry are used to participating in rigorous, transparent and well conducted testing in order to make technical advances and establish technical principles. It is alarming

[4] Comments of the Globalstar filed in FCC IB Docket 13-213, dated September 10, 2015

> that Globalstar thinks that conclusions can be drawn when such testing has not been conducted in this matter.[5]

It is to be expected that the equipment used in TLPS systems will change as the companies involved respond to business opportunities. It is entirely reasonable to expect that any company will be alert for new opportunities and seek to serve needs that have the potential to return profitable additional revenue streams. It is simply good business for companies to optimize and reduce their equipment and operation cost, as they maximize operating efficiency and profitability. Therefore, whatever initial system is deployed, it will almost certainly change over time as Globalstar appropriately seeks to maximize its profits.

Maximum transmit power is just one important parameter that can be expected to vary as Globalstar seeks to maximize its revenue and profit. It is true that most Wi-Fi devices transmit at ~100 mW (20 dBm) and that the 3GPP specifications limit LTE UE to 200 mW (23 dBm). However, a review of FCC equipment grants finds that approximately 5% of Wi-Fi devices transmit with power over 500 mW and similarly there are a number of LTE UE devices with transmit power in that range.[6] Often these are specialized devices. Some are focused on the needs of plant service personnel who need connectivity in more remote locations with poor signal strength. However, there is nothing to present such devices from coming into more mainstream use. Indeed we are

[5] Comments of the Bluetooth SIG filed in FCC IB Docket 13-213, dated October 23, 2015, pg. 2.

[6] We recognize that a number of these higher power devices have special applications and are not in general use. As a result if the comparison is to the number of devices encountered the number is likely to be less than this comparison, which looks at product models. However, we are unaware of anyone who had solid data on the power of devices encountered in various typical use case scenarios. Further, in our own work we are finding it necessary to increase transmit power in order to give our customers the level of reliable service we want for them. We believe as congestion increases a growing number of product planners will face similar pressure to increase transmit power. Hence, we believe that an accurate representation is that currently the transmit power of devices is a distribution and there is good reason to believe that the mean power will increase as band crowding increases. For the issue in this docket the question should be what will the response be should Globalstar deploy and what is the spectral congestion post both deployment and affected parties adjust to it?

already finding that crowding in this band is requiring our products to transmit at higher power in order to achieve adequate reliability. The proposed FCC service rules limit for FCC Part 25.149 (4)(iii) are:

> The maximum transmit power is no more than 1 Watt with a peak EIRP of no more than 6 dBW;

The question to be considered is whether there is adequate interference protection with devices operating up to the proposed 1 Watt limit? We believe our experience is representative and as crowding in this band increases transmission powers will increase as companies seek adequate communication reliability. This question is particularly compelling when it is observed that no out of band emissions limits are proposed for the side of the transmission adjacent to the 2.4 GHz ISM band.

Perhaps an illustration of how testing specific cases can result in confusion with the general case is demonstrated in the curious finding that by adding a single TLPS channel aggregate throughput is increased 90%. In their September 10, 2015 filing Globalstar reports:

> By adding an additional 22 MHz channel (TLPS Channel 14) to the campus' 2.4 GHz Wi-Fi network, users experienced increased aggregate throughput in excess of 90%. Significantly, due to the ability of TLPS to relieve existing Wi-Fi congestion immediately, this near-doubling of network throughput after the introduction of TLPS allowed for an improved experience for all users regardless of whether they remained on Channels 1, 6 and 11 or were operating on Channel 14.[7]

It is hard to understand how increasing system capacity by 33% can result in a 90% increase in throughput other that in very specific circumstances. As Globalstar states there are 3 non-overlapping 22 MHz Wi-Fi channels in the 2.4 GHz ISM band, channels 1, 6 and 11. Adding a 4th 22 MHz Wi-Fi channel, channel 14 increases the channels

[7] Globalstar filing in FCC IB Docket 13-213, dated September 10, 2015.

available from 3 to 4. How it can be generally true that increasing capacity by 33% can result in 90% increase in throughput?

A further significant point related to the reported increase in capacity is that Wi-Fi has the 5 GHz channels to use should extra capacity be needed. If the full set of Wi-Fi channels is considered the extra capacity contributed by allowing operation on channel 14 is relatively minor.

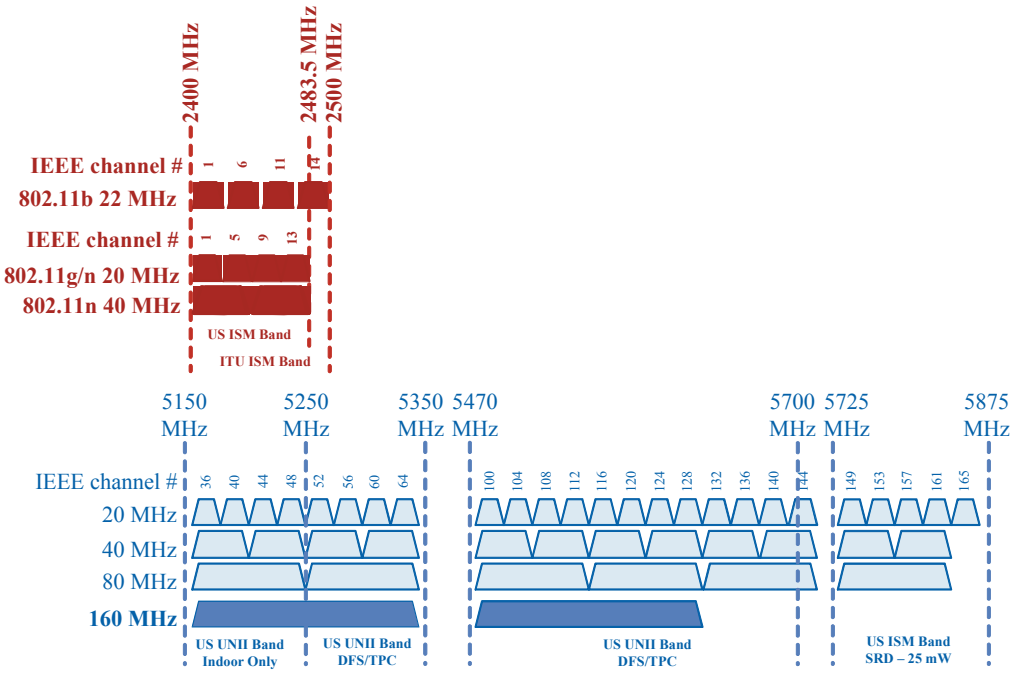

Figure 5 - Wi-Fi channel assignments

However, Bluetooth, Bluetooth LE and devices like our Companion Mic only have the 2.4 GHz ISM band to operate in. These power sensitive devices cannot operate at 5 GHz due to the increased power and resulting battery limitations. Therefore these products and the real-time voice services they provide should be given a priority in evaluating the potential impact of this proposal.

Many flaws exist in the proposed service rules. To cite only one, there is an out of channel emission limit on the upper frequency boundary but none on the lower frequency boundary. This lack of any out of channel emission protection on the side adjacent to the 2.4 GHz ISM band means that an unlimited amount of interference could be injected into the ISM band with no violation of the FCC rules. Should there be any cost savings or other advantage to TLPS devices having high levels of out of channel noise and spectral pollution into the 2.4 GHz ISM band there is nothing in the proposed service rules to prevent that.

A second flaw in the testing provided is failure to evaluate the impact on Bluetooth Low Energy (Bluetooth LE) communications. Bluetooth LE has an entirely different RF profile from Bluetooth or Wi-Fi and is increasingly important for the emerging Internet of Things (IoT), sensors, medical devices and for hearing instruments. Bluetooth LE identifies three advertising channels. These advertising channels are used for devices to find each other and initiate communication. Texas Instruments has a very helpful report about the Bluetooth LE advertising channels, Bluetooth® Low Energy Beacons.[8] They state that the Bluetooth LE advertising channels, numbers as Bluetooth LE "channels 37, 38 and 39 have been chosen to not collide with the three most commonly used Wi-Fi channels; 1, 6 and 11."

[8] Texas Instruments Application Report SWRA475–January 2015, Bluetooth® Low Energy Beacons

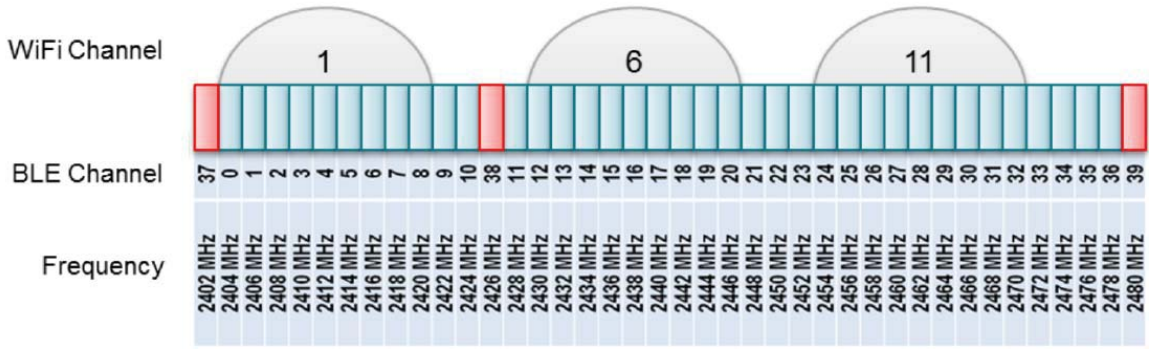

Figure 6 - Bluetooth Low Energy and Wi-FI channels in the 2.4 GHz ISM band[9]

In its report TI goes on to state:

> However, Wi-Fi has significantly higher output power, up to 23 dBm compared to maximum allowed 10 dBm for Bluetooth low energy. This means that placing a beacon very close to a Wi-Fi source will probably distort the transmitted data as spurious emissions on side channels of the Wi-Fi unit will almost always occur on a non-ideal RF product...[10]

[9] ibid, Figure 7, pg. 8.
[10] ibid, pg. 8.

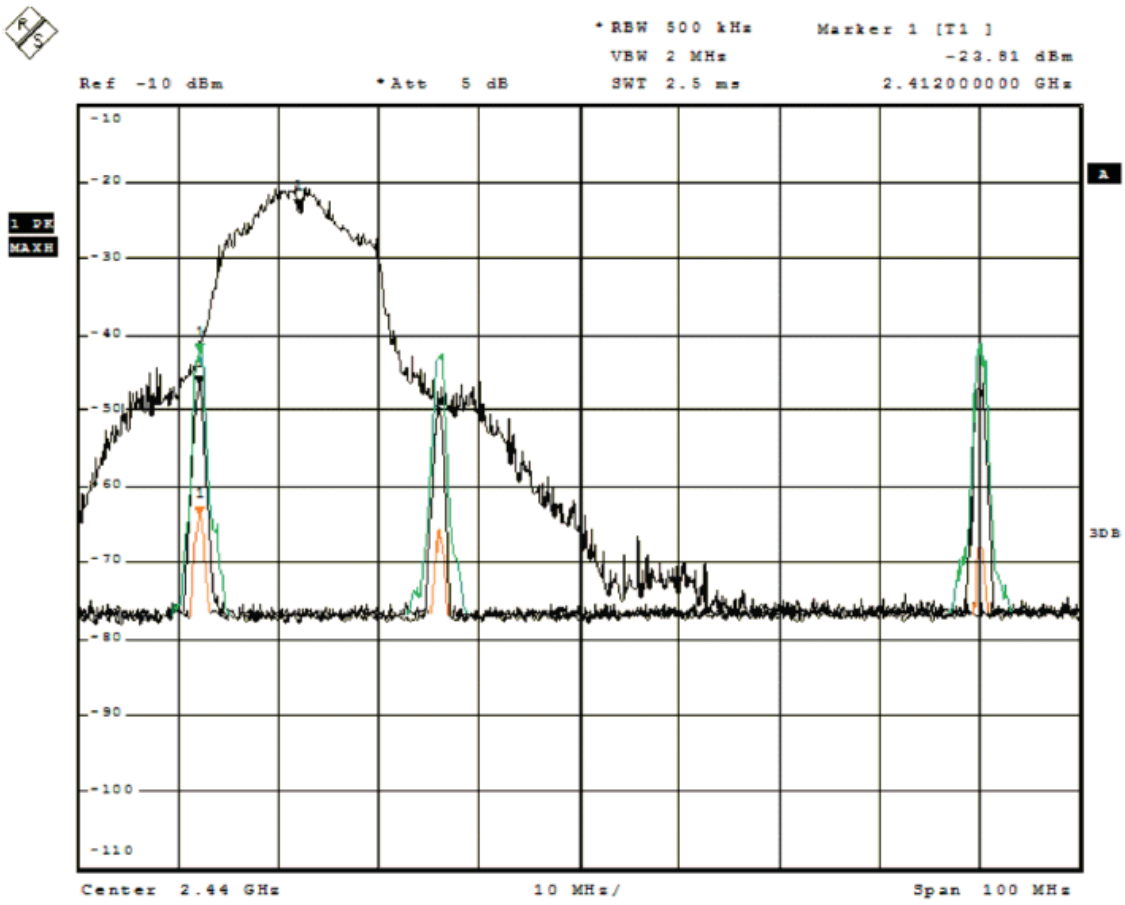

Figure 7 - Spectrum for Wi-Fi Channel 1 versus Bluetooth LE Advertising Channels[11]

In the growing number of locations all three Wi-Fi channels are used and block two of the three Bluetooth LE advertising channels. Examples of the kinds of places where this is true are hospitals, airport terminals, convention centers and other places where many people congregate. In these locations the one advertising channel that is left is the highest frequency of the three channels. In these location this channel is currently the safe-haven, allowing Bluetooth LE devices to find each other and begin communication. If this NPRM is approved Globalstar's system would block that last available advertising channel, totally preventing Bluetooth LE operation in these locations.

[11] ibid, Figure 8, pg. 8.

Reproduction of test results in independent laboratories is a fundamental component of research. However, Globalstar continues its failure to provide sufficient detail for others to reproduce their results or compare their tests to what is being allowed in the proposed FCC service rules. What is needed is sufficient detail to allow others to reproduce Globalstar's testing. Following that the proposed service rules must be carefully scrutinized to ensure that what is tested represents the most interfering possibility under those proposed rules. In contrast what has been tested is far less than what would be allowed under the rules and even that testing cannot be independently confirmed because the specifications have not been made public.

In a farcical proposal to protect other uses from interference Globalstar offers a 1940's era remedy with operators and a hotline for anyone who thinks the Globalstar system is causing interference to call. With Globalstar transmissions, when a person with hearing loss needs to use their assistive device they will not know why it doesn't work. They will just know that it doesn't work. But even if they did know that it was Globalstar pollution that was blocking their assistive technology, and could locate the phone number to call, there is usually not time to call an operator. Based on other experience, the result may in many cases be an empty promise that the network managers would look into it. Globalstar states:

> Globalstar's NOS will not only authenticate clients onto the TLPS network, but will also provide a platform for operators of licensed and unlicensed services to quickly provide notice to Globalstar of any claimed interference to their services.[12]

Globalstar further states:

> Globalstar has identified the existing ViaSat Wi-Fi network management system as an ideal platform for the TLPS NOS. ViaSat's system provides a proven and robust capability to control access to wireless networks and implement corrective

[12] Globalstar filing in FCC IB Docket 13-213, dated September 10, 2015.

> responses. The management system provides for a communication hotline where any problematic interference zones can be identified. [13]

Then in an illustration on the annex the further describe:

> ⑥ If TLPS is suspected of causing harmful interference to adjacent or co-channel licensed or unlicensed services, then ViaSat Support can be notified via hotline. TLPS APs within likely Interference Zone, if any, are identified.
>
> ⑦ ViaSat Support may determine whether TLPS APs within the likely Interference Zone are operating pursuant to specifications and/or may remotely modify emission characteristics of those TLPS APs. Depending upon nature of reported interference, modifications may include (a) reduction in ERP, (b) migration to public channel, or (c) deactivation.[14]

By that time all that happens very likely days or weeks will have passed and the person will have lost the opportunity to have their conversation or conduct their business. It is hard to understand anyone offering such an impractical solution to the interference that they recognize will occur.

This kind of hotline service is in fact being used at many airports. The requirement is a 'feel good' addition put in by people who do not have much experience with wireless networks and their management. Such a hotline requirement is relatively common as a contract requirement from airport authorities to the network operator being awarded the contract. When researchers for the Transportation Research Board ask for records of interference calls last year not a signal interference record was available from any of the airport authorities interviewed.[15] However, those same researchers, using spectrum analyzers and packet capture software had often just measured at those same

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[13] Globalstar filing in FCC IB Docket 13-213, dated September 10, 2015, pg. 2 of the TLPS NOS Management Annex.
[14] Globalstar filing in FCC IB Docket 13-213, dated September 10, 2015, pg. 3 of the TLPS NOS Management Annex.
[15] This research was conducted during the development of ACRP Report 127: A Guidebook for Mitigating Disruptive Wi-Fi Interference at Airports, available at:

://www.trb.org/main/blurbs/172272.aspx

airports high levels of congestion and interference to and between the Wi-Fi network of the airport and other transmitters, most dominantly other Wi-Fi transmissions operating independently and often disrupting the facilities network. Users don't call hotlines. They suffer the consequences of the interference and get on their plane or otherwise go on with their lives, having lost the opportunity to communicate or access the data they were seeking.

A further concern with hotline services is their utility to all users, particularly those with hearing loss. How do you respond to the automated "Press 1 to report an interference issue" when your hearing aid has stopped working because of the interference? To report interference that user would have to go to an area where there is no interference to make a report. At that point wouldn't most people just conduct their business and go on? People with disabilities are amazingly creative and adaptive. However, we should not be creating systems creates additional barriers for them to adapt to. The system should facilitate their objectives and not the reverse.

For such a system to have any merit it must be part of a spectrum etiquette, required by the FCC rules, such as the etiquette used in the UPCS band. The system must be automatic and allow other users of the spectrum a realistic opportunity to benefit from it. How is a Bluetooth or very energy efficient Bluetooth LE device to notify the TLPS system? As TLPS communicates with either Wi-Fi or LTE it must be assumed, unless further information is provided, that notification must be given either by a person calling a hotline or by their device using Wi-Fi or LTE. Few users will have the equipment and technical skill to prove the problems they are having are due to interference from the Globalstar system. If their device were to notify the Globalstar

system, a Bluetooth or Bluetooth LE device must then either add a Wi-Fi or LTE radio or be unable to notify the system. A notification system that requires adding another radio to every device desiring protection, adding cost, complexity and additional battery drain on those devices is completely insufficient. Especially for sensors and other low power devices the burden of adding another radio and even the power drain to periodically notify the TLPS that it was about to transmit would be impossible.

Yet another problem is the coverage of the notification system. Will every user device be required to receive and forward notifications to the system? If not many low energy devices will receive interference from TLPS user equipment but be too remote to notify the TLPS access points because of their low transmit power. To be effective an interference notification system must be designed with an understanding of how the developing internet of things with many low power sensors and other short data transmissions from very power sensitive devices will operate.

Most fundamentally no modifications to the proposed service rules are suggested to require the notification system, no metrics are defined for its performance and no cooperative testing with manufacturers of other devices is provided to demonstrate that the suggested system has any significant value in reducing interference. Cooperative testing is required to demonstrate that such a system in fact works as promised. Then service rules are needed which insure that any implementation of the system, compliant with the proposed rules, would provide adequate interference protection. Without such testing and enforceable service rules the offered protection must be assumed to be nothing more than a meaningless promise.

Globalstar makes another meaningless promise when it states:

> Moreover, Globalstar commits not to deploy LTE-U in the 2.4 GHz band until the Commission has otherwise allowed LTE-U deployment to proceed in unlicensed spectrum.[16]

As Globalstar knows well, or should know well, LTE can be implemented to operate under the current FCC Part 15 rules. No Commission action is required for LTE-U to proceed. Therefore, this promise must be understood as stating nothing more than that Globalstar will not deploy LTE-U in the 2.4 GHz ISM band until it decides it is in its business interest to deploy it.

A question that might be asked is, "Bluetooth works in Europe, and they allow Channels 12 and 13, so why would TLPS be a problem here?" First, there have been problems in Europe and the recent and very significant changes to the ETSI standards and European Norms (EN) for this class of equipment are in response to those problems. The new versions of the ETSI and EN standards add substantial testing to assure that spectrum sharing is effectively performed in all devices. Beyond those regulatory differences, the situation in Europe is very different from that in the US. Compared to the US, in Europe relatively low power Wi-Fi is used. They don't allow high power transmitters or repeaters. Domestic routers are set for around 14 dBm, compared to similar models in the US which are often over 20 dBm. The new version of the ETSI standard and EN limit devices to be under 20 dBm. In addition architectural losses tend to be greater due to thicker walls and more RF absorbing materials being used.

We continue to be concerned that there is not sufficient technical specificity to allow a thorough analysis of the system's impact on other users of the band, such as our Etymotic Research products. However, if the system operates to the limits of the proposed FCC rules in this docket, there is considerable reason for concern that an

[16] Globalstar filing in FCC IB Docket 13-213, dated September 10, 2015.

excessive level of harmful interference would result. We share in this regard the concerns of the Bluetooth SIG, Wi-Fi Alliance and others.

We have read the proposal of the Hearing Industries Association (HIA) that more testing, conducted under the supervision of a neutral third party, such as ANSI ASC C63® is needed. We believe Google's suggestion that an expansion of the 2.4 GHz ISM band has merit. If the band were to be expanded a great deal of benefit would be delivered to the many users of the band. Even then the service rules and implementation timeframe would need careful study. As the band is currently established a number of different services have found a way to share it effectively. A relatively efficient and successful ecosystem is serving the need of Wi-Fi, Bluetooth, Bluetooth LE and Zigbee users. While expanding the band has significant long term merit there could be transitional disruptions to the balance that is currently operating, potentially creating avoidable disruptions during a transition period. We are confident with cooperative effort a workable transition plan could be developed to minimize disruptive impacts of a band expansion.

We continue to have grave concern with Globalstar's representations about lack of impact to audio quality. Assessing the psychoacoustic impact of interference is a specialized topic. The impact of interference on people with normal hearing is different from that on people with hearing loss. We see no effort to study this important topic in any quantified way in the latest demonstration.

Therefore, until such time as there is clear and compelling evidence that consumers of Etymotic products, which enable them to continue living

independently will not be harmed by changes in regulations, we are strongly opposed to the FCC approving the Globalstar proposal.

Respectfully submitted,

Etymotic Research Inc.

By: _____
Mead C. Killion
CTO and Founder, Etymotic Research, Inc.

Date: 30 October 2015